Developing a BIM based asset management strategy – first highlights from specific client case study

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Abstract

Asset managers require meaningful asset data in order to effectively manage their assets. Asset owners from the public and private sectors are increasingly adopting Building Information Modelling (BIM) in the lifecycle of their investments in order to improve asset data delivery, operations and maintenance practices. Despite this momentum, there is insufficient understanding by asset owners of the right standards, processes and policies to follow in delivering such data. Therefore, further awareness and research are needed to develop good BIM implementation practices in the Architecture, Engineering, Construction, Owner and Operator (AECOO) industry in order to improve the adoption of BIM-based processes by asset owners. The paper seeks to understand the current Asset Management (AM) methods and further aims to develop a BIM-based AM strategy that focuses on the development of a consolidated Asset Information Model (AIM) that can support building information management with the optional requirement of 3D-models in a specific client case study. The case study is a public asset owner that manages residential buildings and social housing. The purpose of the paper is to frame, evaluate and test the defined strategic approach based on organisational requirements and established AM development stages. The first stage which is covered by this paper involves the development of a BIM-based AM strategy that is based on non-graphical data and documentation. The research, methodology and outcomes led to the following results: (a) developing better understanding by the asset owner and improved awareness of the difficulties of implementing the defined BIM-based AM strategy in a practical case study; (b) identifying generic barriers and obstacles relating to the implementation of a BIM-based approach in managing asset data of all building stock owned by the public asset owner; (c) highlighting direct uses of the strategy and benefits towards future asset operation and maintenance actions; (d) demonstrating the business value of BIM across building maintenance actions and new construction processes.

Keywords: Data, information, COBie, Asset Operations, client requirements

1. Introduction

Building Information Modelling (BIM) represents the consistent and continuous use of digital information across the entire lifecycle of a built asset, including its design, construction and operation (Borrmann, König, Koch & Beetz, 2018). Comparative market analysis studies (Kassem & Succar, 2017) evidence that BIM adoption ranges from country to country, with each having distinct strategies. BIM adoption is now a common feature of the Architecture, Engineering, Construction, Owner and Operator (AECOO) industry in many countries around the world. This methodology is aimed at accelerating the pace of the AECOO industry towards new levels of efficiency, sustainability and productivity. Despite the misunderstandings around BIM (Hjelseth, 2017), stakeholders in the AECOO industry are interested in deriving BIM benefits from all phases of asset development, even though they lack extensive knowledge of process-based requirements and implications (Grussing, 2013). There have been more studies on the benefits of BIM during the design and construction phases, with few focusing on its implementation and potential benefits in asset operations and maintenance (Love et al., 2014). Furthermore, little research interest has been evidenced in investigating the uses of BIM in post-handover project processes and in developing BIM adoption strategies for existing buildings (Eastman, Teicholz, Sacks & Liston, 2011; Carbonari, Stravoravdis & Gausden, 2015). A growing perception of BIM amongst stakeholders in the AECOO industry is that BIM facilitates Knowledge Management (KM) activities including acquisition, extraction, storage, sharing and updating of building information in a structured way right through an asset's lifecycle (Deshpande et al., 2014). This becomes interesting when data from the building information model may help to prevent information or knowledge breaks during major refurbishments or as a result of change of ownership of the built asset (Borrmann et al., 2018).

This research is developed from the asset manager or asset owner perspective and is aimed at focusing on the benefits and challenges of implementing BIM in Asset Management (AM). This study views BIM from the perspective of Building Information Management (Parsanezhad & Dimyadi, 2014). Furthermore, the scope of this study focuses on the implementation of BIM for existing buildings. In this context, the development of a BIM-based AM strategy for built assets that have been in service for several decades and will continue to be in use for many years with major, minor or even no interventions carried out. This is necessary because maintenance actions and operation costs can be three times higher than construction costs and five to seven times higher than the initial investment costs (Grussing, 2013; Korpela, Miettinen, Salmikivi, & Ihalainen, 2015). On this premise, the outcomes of this study can contribute to effective asset maintenance and management strategies, thereby leading to the reduction of the global asset operation costs in the long-run. The contributions can be even more relevant when carrying out asset intervention actions where it is possible to leverage on the data provided by the building information models in decision-making regarding the best design solutions and products that have proven durability and savings as well as environmental and energy efficiency targets and performance.

The paper seeks to understand the current AM methods in a specific client case study. Also, the paper aims to develop a BIM-based AM strategy that focuses on the development of a consolidated Asset Information Model (AIM) that can support building information management with the optional requirement of 3D-models. The case study is a public asset owner that manages residential buildings and social housing. The purpose of the paper is to frame, evaluate and test the defined strategic approach based on organisational requirements and established AM development stages. The first stage which is covered by this paper involves the development of a BIM-based AM strategy that is based on non-graphical data and documentation.

2. Review

2.1 Building Information Management

Over the building life-cycle, the amount of graphics and data required varies from stage to stage (Carbonari et al., 2015). Figure 1 shows the schematic evolution of the growing relevance of information throughout the life-cycle of an asset.

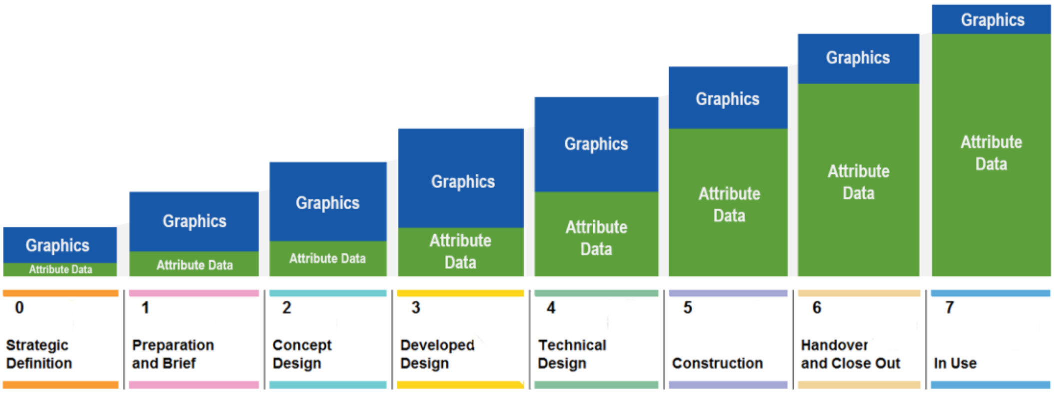

Figure 1: Graphics and Data evolution over construction life-cycle (adapted from Carbonari et al., 2015; PAS 1192-3 (BSI, 2014) and RIBA, 2013)

Despite this awareness, many studies have focused on developing strategies to deliver extensive graphical models for building operations (Volk, 2014). Similarly, 3D-geometric data is reported to have little value in AM tasks (Munir, Kiviniemi, & Jones, 2019). The same assume that asset owners have difficulty on following and understanding the effort of the work. This occurs mainly due to the cost of the process and due to the absence of direct added value of the deliverables/result (Kassem & Succar, 2017). Furthermore, the nature and type of a building would influence the process-based strategic definition for BIM-based processes in AM. For most asset owners, their main concerns are geared towards asset characterisation and information delivery. However, there are situations where the development of a detailed 3D graphical model may be useful, for instance, the case of Heritage buildings. The recent events at Notre-Dame highlight the utility of a graphical model. Notwithstanding, the availability of graphical information can be an accessory at the initial stage or it can be produced in subsequent asset development phases in line with the main strategic requirement of the asset owner, which is to improve the knowledge and management capability for the built asset. The strategic approach in relation to the development of building information should be from the "Information to Graphic" perspective as opposed to the "Graphic to Information" order, by focusing on the identification of key datasets to create the (non-graphical part of the) AIM (Carbonari, et al. 2015).

There are AECOO industry standards such as Information Delivery Manuals (IDM), Industry Foundation Classes (IFC), Model View Definitions (MVD), buildingSMART Data Dictionary (bsDD) and BIM Collaboration Format (BCF) that have been developed for the creation, exchange and management of building information from design and construction stages to the operations and maintenance stage (Mêda, 2014; Cavka, Staub-French, & Poirier, 2017). Despite the development of several frameworks using one or more of these standards, IFC and Construction Operations Building Information Exchange (COBie) are the two main open source schemas that fulfil the exchange requirements for BIM-based information exchange in AM (Eastman et al., 2011). The AIM, despite using a common structure, can assume very distinct goals depending on the construction type, nature of ownership, and operations and maintenance strategy (Grussing, 2013).

2.2 Construction Operations Building Information Exchange (COBie)

The UK Government BIM strategy has led to the development of several guidelines and standards. Despite the efforts on technological standards, this approach is robust from the process viewpoint. Meaning that there is a strong concern in relation to the global achievements intended with BIM as well as balancing the different aspects of the implementation process (technology, processes and people) (Hjelseth & Mêda, 2016). In respect with the handover of construction information and utilisation of data in the operational stage of built assets, PAS 1192-3 (BSI, 2014a) and BS 1192-4 (BSI, 2014b) constitute the main guidelines. The first provides and overall vision of the lifecycle structure of BIM including specifications on the purpose of maintenance and the information requirements towards the implementation of Level 2 BIM of the UK strategy. On the other hand, BS 1192-4 (BSI, 2014b) or COBie provides further orientation on the information requirements by setting the framework for data exchange between applications and databases throughout the facility's lifecycle. Figure 2 presents COBie worksheets (blue, yellow, green, grey) that have been utilised in developing the BIM-based AM strategy in relation to the asset development phases. The tables highlighted in grey have been excluded from the strategy at this stage.

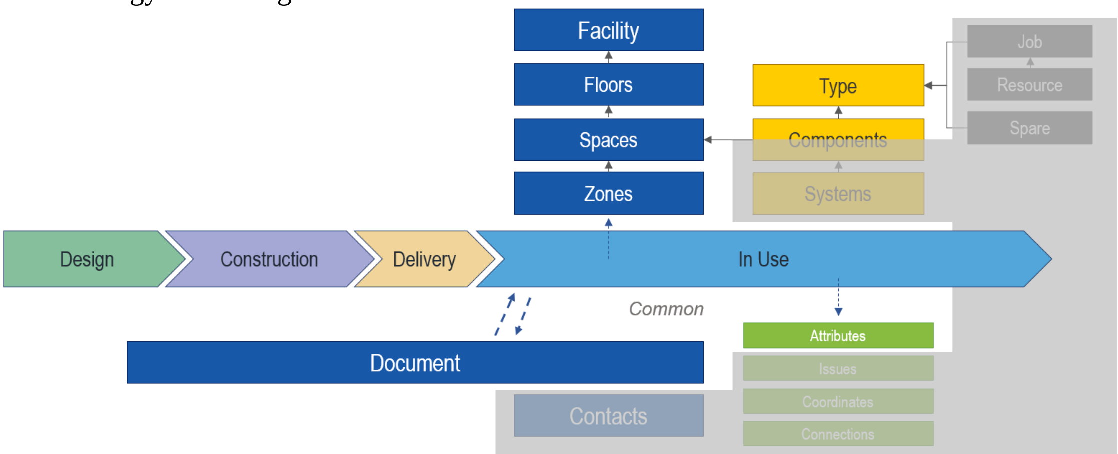

Figure 2: COBie tables utilised within the context of the developed study

2.3 Benefits and Barriers

A significant amount of existing buildings have more than one decade of service and many of them have more than one century. Considering the foregoing, it can be said that most of them do not belong to the "BIM era" as "traditional" approaches and formats such as CAD, .doc, .pdf documents, paper or a mix of both were utilised during asset development. Paper documents can range with several different contents to support the design and construction stages, depending on the moment they were produced. Even in situations where all the processes are structured and well supported, the information required for the development of the AIM is generally scattered, incomplete and inaccurate. Furthermore, the building can change ownership many times and this factor can lead to a total absence of project documentation or knowledge gaps. Notwithstanding, a streamlined definition and the organisation of essential and relevant datasets can facilitate the recreation of information that will produce a satisfactory AIM. This would enhance the asset manager's awareness on facility data and condition, thereby minimising knowledge gaps throughout the lifecycle. To make it possible, combined data analysis from documents with data capture from on-site inspections followed by data modelling are techniques that can be utilised to develop an AIM. In fact, site inspections can be very productive and worthy if the strategy integrates condition analysis of construction elements. Furthermore, in terms of business value and from a general perspective, the potential benefits of BIM are presented in Table 1 (Hossain, 2014):

Table 1: BIM for operation, maintenance and sustainability (Hossain, 2014)

Item	*Description*
Lifecycle analysis	Facility/asset management, monitoring, 3D visualisation, real time data access, maintenance schedule, auditing, emergency management
Retrofit	Retrofit decision making, repair and reconstruction
Energy	Building energy modelling, energy efficiencies and energy conservation
Safety	Safety facility management, hazard mitigation, fall prevention, fire prevention and disaster relief, integrated multidisciplinary model for security and safety management
Sustainability	Sustainable facility management, sustainable retrofit
Decommissioning	Analysing material composition prior to demolition

3. Methodology and Research Question

This paper is part of a study that aims to develop a BIM-based AM strategy in order to streamline the processes of a public asset owner that manages residential buildings and social housing. At this stage, the study is focused on the development of a consolidated AIM that can support building information management with the optional requirement of 3D models. This is due to the fact that all the projects were developed prior to BIM and most project documentation such as drawings only exist on paper. Furthermore, this study seeks to identify the asset owners' requirements and challenges in terms of documenting building information in order to develop and implement the strategy as well as the inherent business value to be derived from the whole process. Based on these assumptions, the following research questions are developed:

- What is the current state of information process management within the organisation?
- What are the strategic BIM-based information requirements of the asset owner?
- How would the new information requirements impact/influence/transform the processes presently in use by the public asset owner?
- What are the potential benefits of these processes?

3.1 Methodological Approach

To develop the study, several steps were identified in order to deliver the outcomes. As a result, two major tasks were developed at the initial stage. The first, investigated the organisation, its structure, main objectives, scope of action, building stock overview, processes and information systems. This task also included the objectives and requirements for the development of the BIM-based AM strategy. The second task identifies tools and methodologies that could fit the study purpose. Furthermore, it identifies information requirements, structures and expected outcomes through literature review. With the accomplishment of these tasks, it was possible to develop the BIM-based AM strategy and test its applicability on the selected case study. The case study is selected based on the following criteria:

i) Senior level management motivation to implement BIM within the organisation and across the building stock.
ii) The existence of change management programmes and recent investments aimed at optimising assets, enhancing maintenance actions and improving future developments as a result of documented building information from historical maintenance activities;
iii) The existence of project-level documentation such as "As-built" drawings, specifications and bill of quantities across the building stock;
iv) The existence of generic construction information across the building stock;
v) The existence of building information regarding all maintenance processes that have been carried out since handover across the building stock.

Figure 3 shows the methodological approach of this study:

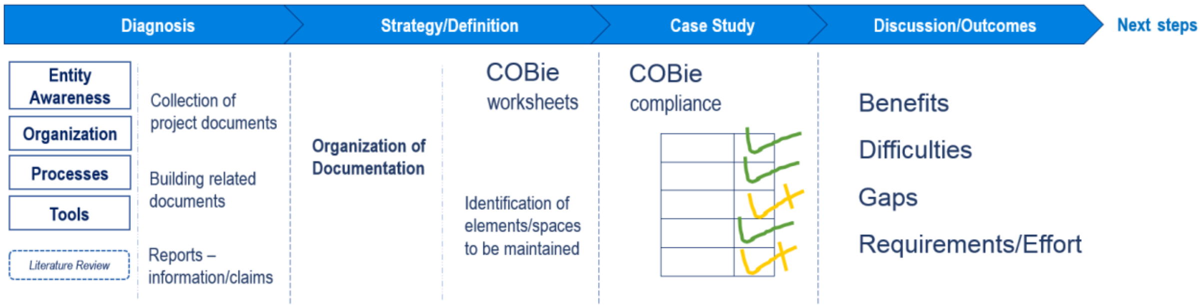

Figure 3: Methodological approach

The case study produced all the essential elements that were used in the development of the BIM-based AM strategy at the information and process level. It also enabled the forecasting of implications in terms of generalisations relating to the remaining building stock. This helped in terms of achieving the necessary information and definition of limits for incomplete data. The last aspect of the study led to a primary perception of the business value of BIM-based processes for the public asset owner at process and management level, as well as future developments.

4. Results: Case Study

4.1 Summary of the Case

An essential step was to understand and achieve a consistent understanding of the information and process level capability within the organisation. The public asset owner under study requested for anonymity but has authorised the use of all data and findings. These findings have been reported in accordance with research ethics and the confidentiality requirements of the public asset owner (Denscombe, 2010). The public asset owner belongs to a Portuguese municipality and has a mandate to manage all the social residential buildings as well as commercial spaces within those facilities. The building stock is composed by nearly 55 facilities built between early 1940's and 2012. These represent a total of nearly 4,500 houses. The public asset owner is responsible for the management of the building stock during operations and use. Usually, the design and construction stages are not managed by the public asset owner but are handled by other entities within the municipality or national agencies related with social housing. These entities later transfer the built assets for use by the public asset owner. As a result of this asset transfer process, the study identified significant knowledge gaps or total absence of project-related documents. Hence, the need for the definition of a strategy and development of procedures that could assure streamlined transfer of all relevant project-related information to the public asset owner.

Other corporate purposes of the public asset owner are social support, lease of houses, and maintenance of common areas of the buildings as well as exterior surroundings. The tenants are responsible for the maintenance of the houses, except where the defects are motivated by problems on or from common areas. This awareness is essential in understanding the boundaries and the type of construction elements and products to be maintained. Besides narrowing the scope of the construction process, it also has influence on the information requirements and economic impacts of the strategy. On the other hand, it was evidenced that the boundaries are somewhat "flexible" causing disturbance on criteria definition. This is due to the size and heterogeneity of the building stock. Furthermore, all claims and maintenance activities from 2013-to date are placed on a proprietary information system. This system supports all the claims and maintenance requests for a specific building or house, which is organised according to system or construction elements and the process follow-up (inspection, budget estimate, tendering (when applicable) and final report) until its conclusion. In addition, the system supports the management of house occupancy, definition of incomes and the required adjustments in relation to the number of households. This system was initially developed and improved according to business needs but it was found to be the main structure for the development of the BIM-based AM strategy. It also provides the data element to compare with other tools in terms of information levels and information requirements or definition.

4.2 Case Study Characterisation

As previously stated, criteria were set for the selection of the building/facility to be used as case study. These were related to the amount of information available from the design and construction stages. Furthermore, the representativeness of the facility in terms of construction solutions on the overall building stock, and the ability to track on-site all the maintenance activities that have been developed since commissioning were crucial for this case study selection. This led to the appraisal of one of the most recent facilities built on the municipality. The building is referred to as “RF_50 – Residential Facility_50” in this study. The architectural design was developed in 2008 and construction started in 2010 (MEP design-build contract). The total project sum for the MEP design and construction represented nearly € 500,000.00. The first houses were occupied in 2012. In terms of volume, the facility is a single building with two floors comprising of 12 houses. The building deployment area is 400 m^2 and the total construction area is around 1,050 m^2. It is a reinforced concrete framed structure with masonry infilling walls and Goth coated flat roof. The facades are finished with ETICS and the window and door frames are made of lacquered aluminium with double glass. The common areas are finished with painted plaster on walls and ceilings and the floor with ceramic tiles.

4.3 Information Management Strategy

The case study lacked existing procedures to manage building information across asset development stages. Therefore, in order to structure the operational information requirements of the asset owner, a first level analysis is conducted. This led to the definition of aspects that are found to be relevant for asset operations and maintenance. The schematic analysis utilised is presented in Table 2.

Table 2: Information management strategy schematic structure

S/ No	Themes	Institution
1	Sector	Residential
2	Strategy	Priority Definition
3	BIM Data Perspective	COBie (ifc)
4	General Structure	1. Attribute-sets definition. 2. Individual elements covered in Object Category below. 3. Individual systems or objects according to business needs
5	Object Category	1. Structure 2. Building fabric shell 3. Plumbing - common areas 4. Lighting - common areas 5. Fire protection 6. Exterior windows 7. Photovoltaic system

The above analysis (Table 2) highlights that the business sector of the public asset owner has a clear relationship with nature and type of information needs. Therefore, this factor will clearly impact the development of the BIM-based AM strategy. The analysis reinforces the logic or premise that information requirements are directly related with the mandate of the entity. Furthermore, there have been maintenance activities that have been carried out by tenants without the knowledge of the public asset owner such as painting, tiling, and electrical plugs, to name few. Hence, the study notes that without total control over all building elements and the execution of maintenance activities, the definition on the BIM-based AM strategy will have a limited scope.

4.4 Information Requirement Analysis

The proprietary information system supports all claims and maintenance activities carried out by the public asset owner. It also deals with substantial information from "Facility" to "House" level. Even though it was not structured and envisaged for BIM-based processes, it meets most of the COBie-level information requirements for the "Facility", "Floor" and "Space" worksheets. The system manages maintenance operations without the technical detail or data of the building components. Despite the two-level structure for categorisation of maintenance actions, the datasets were not suitable for populating the "Component" and "Type" worksheets. For the identification of the of the requirement type data, the study evaluates documents produced at design and construction phases, namely; bill of quantities, drawings, specifications and on-site inspection reports and visits. In addition to these information sources, there are other documents developed by the public asset owner that helps to systematise relevant data in relation to the facility. From these documents, more than Fullfil were identified. These are referred to as "management documents". Furthermore, for the purpose of implementing COBie, standard breakdown structures were identified and incorporated into the process either from legal documents or AECOO industry standards. Figure 4 presents the summary of information sources available within the public asset owner in order to fulfil the main information fields of the COBie worksheets from "Facility" to "Type" level.

Facility	Sources of information	Comments
Name	• Δ □ ◊	different names - standardization is required
Category	□ ∷	
Project Name	Δ ◊	
Site Name	•	
Area Measurement	□	
Description	∷	
Project Description	• Δ □ ◊	
Site Description	• Δ ◊	
Phase	∷	

Floor		
Name	• Δ ◊ ✶	
Category	• ◊ ✶	
Description	✶	
Elevation	◊ ✶	
Height	◊ ✶	

Space		
Name	◊ ✶	
Category	✶ ∷	
Floor Name	• Δ ◊ ✶	
Description	• ◊ ✶	
RoomTag	•	not for all
UsableHeight	◊ ✶	
GrossArea	◊ ✶	
NetArea	◊ ✶	

Zone		
Name	•	
Category	• ◊ ✶	
Space Names	◊ ✶	
Description		need to be defined

Component		
Name		requires asset classification
Type Name	• ◊ ✶	
Space	◊ ✶	
Description	◊ ✶	
SerialNumber		requires asset classification
InstallationDate		not traceable in most situations
WarrantyStartDate	• Δ	
TagNumber		requires asset classification
BarCode	✶	in some might be dificult to achieve
AssetIdentifier		requires asset classification

Type		
Name	• ◊ ✶	
Description	◊ ✶	
AssetType	◊ ✶ ∷	
Manufacturer	◊ ✶	
ModelNumber	◊ ✶	
WarrantyGuarantorParts		depend of products
WarrantyDurationParts	□	
WarrantyGuarantorLabor		not traceable in most situations
WarrantyDurationLabor	□	
WarrantyDurationUnit	□	
ReplacementCost	•	inputs from the system not from the product manufacturer
ExpectedLife		(*)
DurationUnit	□	
WarrantyDescription		need to be defined
NominalLength	◊ ✶	
NominalWidth	◊ ✶	
NominalHeight	◊ ✶	
ModelReference	◊ ✶	in some might be dificult to achieve
Shape	◊ ✶	
Size	◊ ✶	
Color	◊ ✶	
Finish	◊ ✶	in some might be dificult to achieve
Grade	◊ ✶	in some might be dificult to achieve
Material	◊ ✶	in some might be dificult to achieve
Constituents	◊ ✶	in some might be dificult to achieve
Features	◊ ✶	in some might be dificult to achieve
AccessibilityPerformance		not defined
CodePerformance		not defined
SustainabilityPerformance		not defined

•	Claim system
Δ	Management documents
□	Legal documents
◊	Project documents
✶	Site inspection
∷	Standards and references

Figure 4: Information sources to fulfil COBie worksheets from "Facility" to "Type" level

The above (Figure 4) information source and requirement analysis helped in the development of the BIM-based AM strategy. The information available allows setting additional attributes to most of the worksheets. In terms of data consistency, discrepancies were identified between the claims system and the project documents. On-site inspection evidenced that data in the project documents were accurate, meaning that some errors might have occurred in entering the data onto the system. Several source definitions were observed for the “Project Description” field, meaning that a standard description needs to be set and updated on all systems and documents. “Component” and “Type” worksheets generally rely on project documents and site inspections. Hence, the developed strategy recommends the re-structuring of these activities in order to take advantage of the opportunity by executing them concurrently with other activities such as the identification of the condition of building components. However, some information fields lack “Component” and “Type” level information. This is found to be the second step and the core of the BIM-based AM strategy because it relies on the definition of the data structure and BIM data perspective by the asset owner. This analysis provided better understanding regarding different aspects of the case study. The first is the discovery that there is a general lack of project-level information. This means that the public asset owner is managing facilities without the entire knowledge of its components. Second, is the understanding that the claims system constitutes an essential tool for managing the facilities but little value is derived for the purpose of general AM. Hence, the strategy highlights the need to address issues regarding project-level knowledge gaps at three levels: a) definition of the basic project information needed; b) tracking data for each facility across systems and project documents (where or if the information is available); c) taking advantage of the claims system either by correcting discrepancies or by improving the information reports and to develop interfaces that are BIM oriented.

5. Conclusions

The purpose of the paper is to investigate the initial stages of the development of a BIM-based AM strategy and to frame, evaluate and test the defined strategic approach based on requirements and established AM development stages set by the asset owner. For the purpose of the BIM-based AM strategy definition, the existence of a claims system is found to be useful as it structures relevant asset information. Another advantage is that it is based on current staff work processes and as a result, there would be no need for process re-engineering. Consequently, this would foster and facilitate the evolution and implementation of new or additional systems by the public asset owner. Notwithstanding, the claims system has its downsides. The study finds information discrepancies that need to be resolved within the system. Furthermore, the case study highlights the challenges and the need to define information requirements including further developments required to deliver a minimum AM strategy based on COBie. The study identifies that the development of the AIM will rely on extensive on-site inspections either to implement the asset categorisation strategy or to identify relevant asset data to fulfil COBie requirements. Also, it highlights the need to re-structure activities and execute them concurrently in order to take advantage of the whole process. The research, methodology and outcomes led to distinct results:

- development of understanding and improved awareness of the difficulties of implementing the defined BIM-based AM strategy in a practical case study (effort, knowledge gaps, others);
- generic barriers and obstacles in terms of general implementation to all building stock managed by the public asset owner;
- direct uses of the strategy and benefits towards operation and maintenance actions;
- business value of BIM (across building maintenance actions, major and minor refurbishment actions, as well as new construction processes).

In conclusion, future studies will be developed based on information delivery guidelines for the public asset owner in executing preventive maintenance actions, major and minor asset interventions as well as the information requirements and performance of technical solutions for new-build construction processes.

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